Fig.1

Next hop Node

Node

Multiple links

Congestion!

Physical link #1
Physical link #2
Physical link #m

Without load balance mechanism

Fig.2

Next hop Node

Node

Multiple links

Physical link #1
Physical link #2
Physical link #m

) With Conventional load balance mechanism

Fig.3

Next hop Node

Node

Multiple links

Physical link #1
Physical link #2
Physical link #m

MPLS Domain

FEC A — Net1 — A1
FEC B — Net2 — B1

FEC B — Net4 — B1
FEC A — Net3 — A1

E1, E2, E3, E4
C1, C2, C3, C4

Link1, Link2, Link3, Link4, Link5, Link6, Link7, Link8
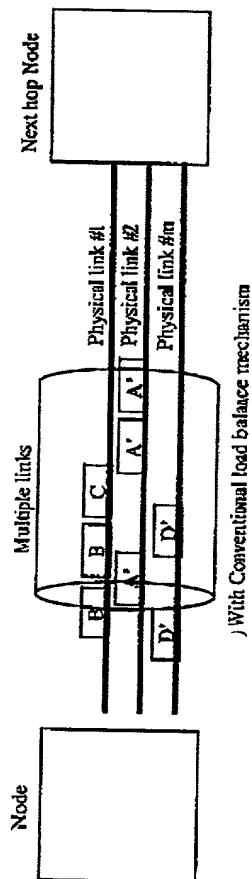
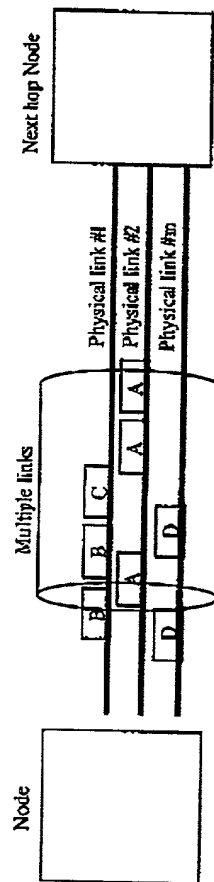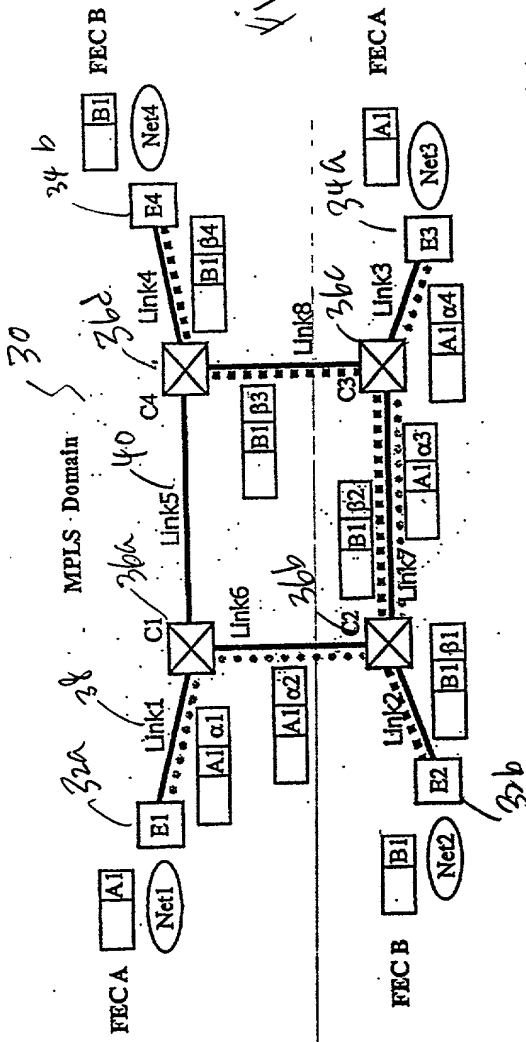A1 | α1
A1 | α2
A1 | α3
A1 | α4
B1 | β1
B1 | β2
B1 | β3
B1 | β4

C1, C2, C3, C4 : Label Switch Router (CORE), E1, E2, E3, E4 : Label Switch Router (Edge),
A1, B1: IP Destination Address, α1, α2, α3, α4, β1, β2, β3, β4 : Label
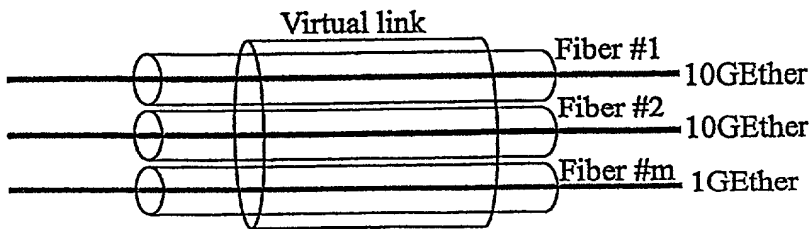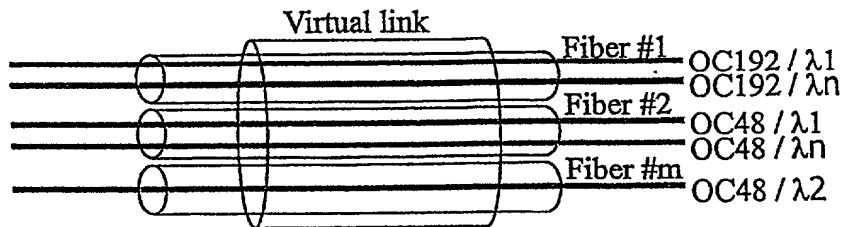
Example of the network (MPLS) domain

Virtual link

Fiber #1 — 10GEther
Fiber #2 — 10GEther
Fiber #m — 1GEther

Fig. 5a

Virtual link

Fiber #1
OC192 / $\lambda 1$
OC192 / λn
Fiber #2
OC48 / $\lambda 1$
OC48 / λn
Fiber #m
OC48 / $\lambda 2$

Fig. 5b

Virtual link

Fiber #1
OC192 / $\lambda 1$
OC192 / λn
Fiber #2
10GEther / $\lambda 1$
10GEther
Fiber #m
1GEther

Fig. 5c

Virtual link

OC192
TimeSlot8
TimeSlot2
TimeSlot19
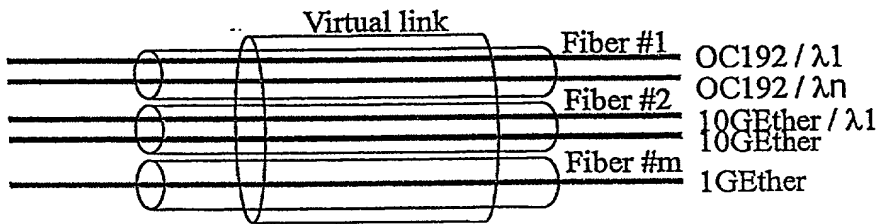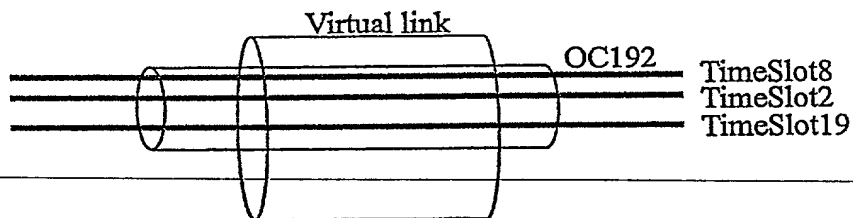
Fig. 5d

Examples of composition of physical and logical links

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Control plane in a node

IP Routing Protocols ← → Routing information

IP Routing Table

MPLS   Routing Control ← → Label binding

→ Virtual link # I1   Virtual link # O1 ⇒

→ Virtual link # I2   Label Forwarding   Virtual link # O2 ⇒

→ Virtual link # Im   Virtual link # Om ⇒

Data plane in a node

Incoming labeled   Outgoing labeled

50
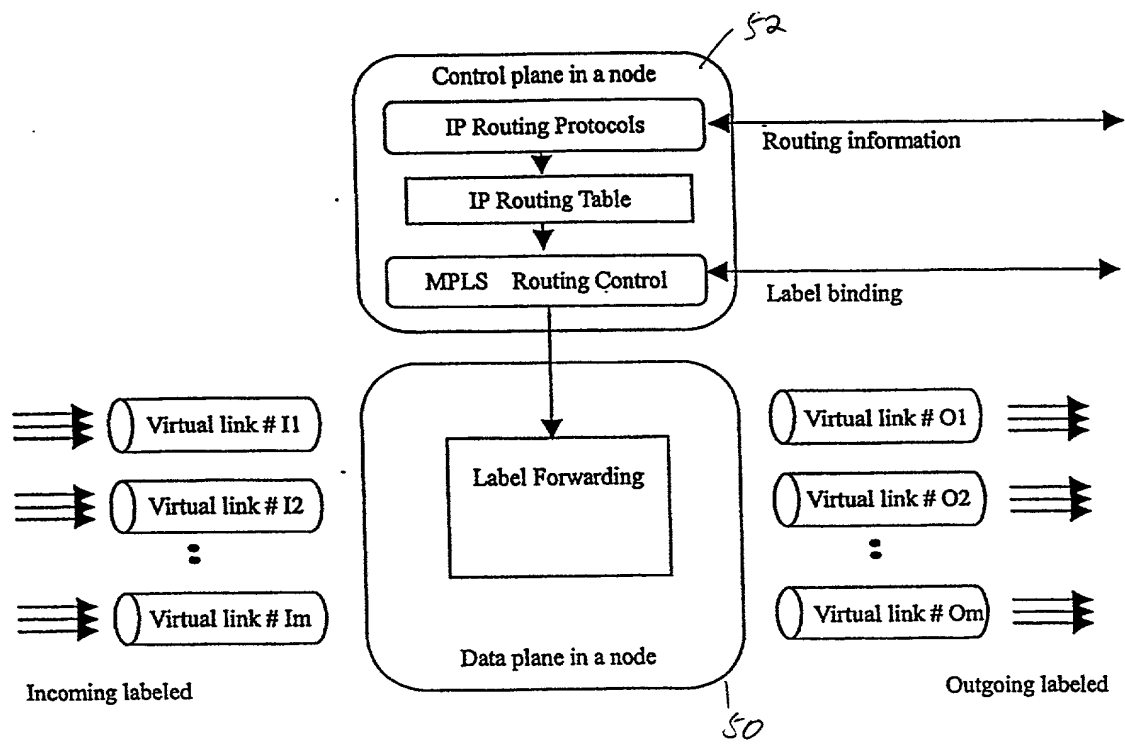
Figure   6   LSR Architecture

Figure 1

Control plane in a node
IP Routing Protocols
Routing information exchange with other routers
IP Routing Table
MPLS Routing Control
Label binding exchange with other LSR's

Port I_{11}
Port I_{1n}
Port I_{21}
Port I_{2n}
Port I_{m1}
Port I_{mn}

Label Forwarding

Port O_{11}
Port O_{1a}
Port O_{21}
Port O_{2a}
Port O_{m1}
Port O_{mn}

path1
path2

Data plane in a node

60
62 64
Incoming labeled packets

Outgoing labeled packets

Figure 2

Control plane in a node
IP Routing Protocols
Routing information exchange with other routers
IP Routing Table
MPLS Routing Control
Label binding exchange with other LSR's

Virtual link #1
Virtual link #2

Label Forwarding

Virtual link #1
Virtual link #2

path1
path2

Virtual link #m

Data plane in a node

Incoming labeled packets

Outgoing labeled packets

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Practical port # n   Practical port # 1

Backplane SW

Virtual link # A
γ   β   α
Virtual port A

LF 1
LF 2
LF n

Virtual link # J
Virtual port J

Virtual link #B
Virtual port B

β'   β'   Virtual link # K
α'   α'
Virtual port K

Virtual link # H
Virtual port H

Virtual link # X
γ'   γ'
Virtual port X

Figure 6(a)   9(a)

Practical port # n   Practical port # 1

Backplane SW

Virtual link # A
γ   β   α
Virtual port A

LF 1

Virtual link # J
Virtual port J

Virtual link #B
Virtual port B

β'   β'   Virtual link # K
α'   α'
Virtual port K

Virtual link # H
Virtual port H

Virtual link # X
γ'   γ'
Virtual port X
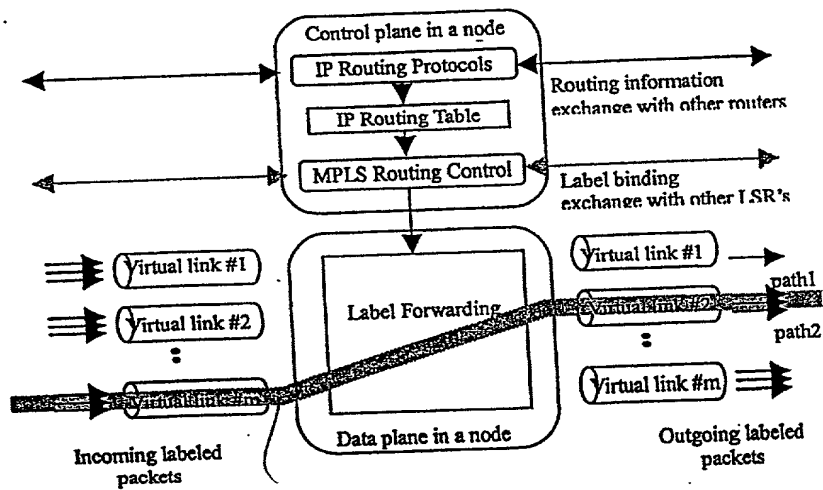
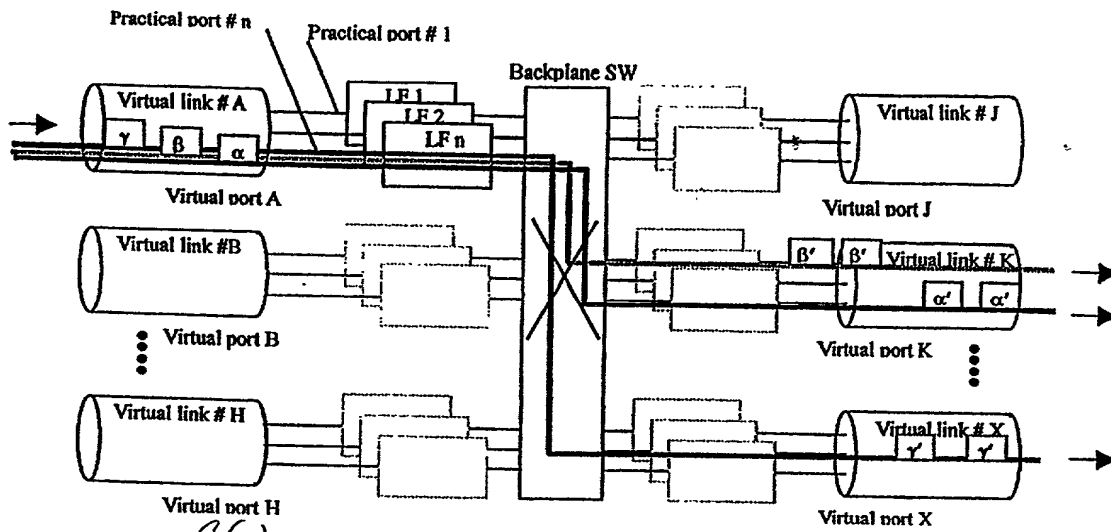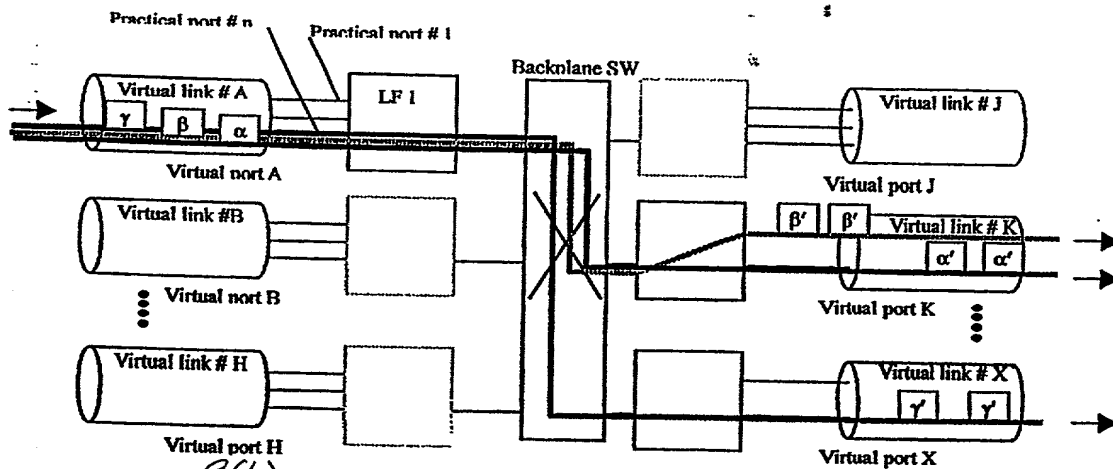Figure 6   9(b)

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Label Forwarding Table maintained by the MPLS control plane

Input practical port #	Input virtual port #	Input Label	Output Label	Output virtual port #	Output practical port #
n	A	α	α'	K	$f(\alpha')$
n	A	β	β'	K	$f(\beta')$
n	A	γ	γ'	X	$f(\gamma')$
2	A	δ	δ'	B	$f(\delta')$
1	A	ε	ε'	B	$f(\varepsilon')$
2	A	ζ	ζ'	H	$f(\zeta')$
1	A	η	η'	J	$f(\eta')$
5	A	σ	σ'	K	$f(\sigma')$
n	A	κ	κ'	X	$f(\kappa')$

Figure 7 Label Forwarding Table and mechanism to decide practical output port at the sending LSR

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Label Forwarding Table maintained by the MPLS control plane

Tag	Hash value of incoming label	Input practical port #	Input virtual port #	Input Label	Output Label	Output virtual port #	Output practical port #
O	$f(\alpha')$	n	A	α'	α''	K	$f(\alpha'')$
O	$f(\beta')$	n	A	β'	β''	K	$f(\beta'')$
O	$f(\gamma')$	n	A	γ'	γ''	X	$f(\gamma'')$
.	$f(\delta')$	2	A	δ'	δ''	B	$f(\delta'')$
O	$f(\varepsilon')$	1	A	ε'	ε''	B	$f(\varepsilon'')$
O	$f(\zeta')$	2	A	ζ'	ζ''	H	$f(\zeta'')$
O	$f(\eta')$	1	A	η'	η''	J	$f(\eta'')$
	$f(\sigma')$	5	A	σ'	σ''	K	$f(\sigma'')$
	$f(\kappa')$	n	A	κ'	κ''	X	$f(\kappa'')$

Figure 8 Fast lookup mechanism using a hash

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